AIR QUALITY AND AIR QUALITY RELATED VALUES MONITORING CONSIDERATIONS FOR THE MOJAVE DESERT NETWORK

May 2004

Introduction

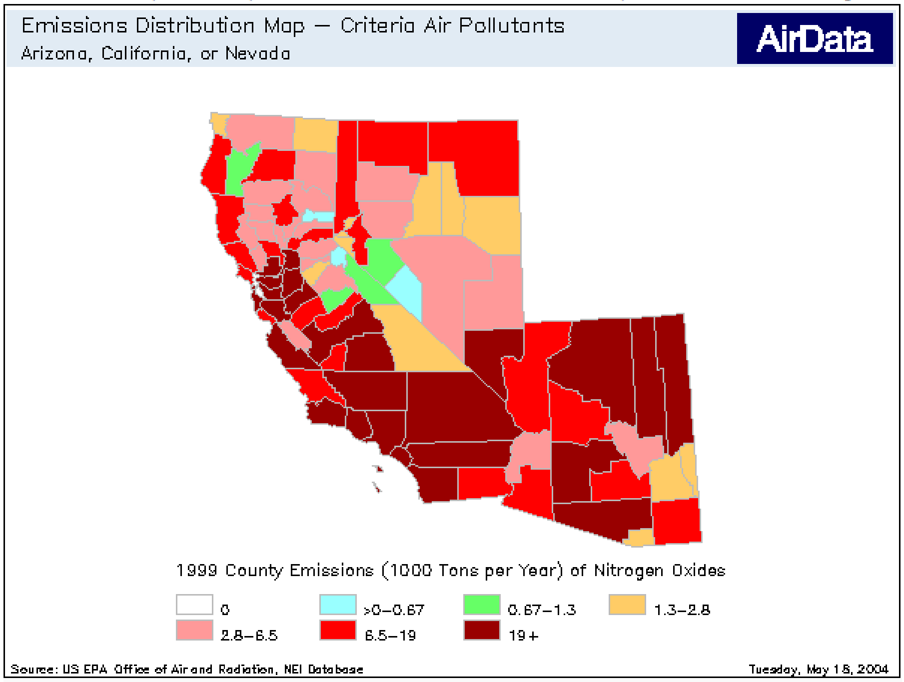
The Mojave Desert Network of the National Park Service (NPS) Inventory and Monitoring Program includes Death Valley National Park (NP), Great Basin NP, Joshua Tree NP, Lake Mead National Recreation Area (NRA), Manzanar National Historic Site (NHS), and Mojave National Preserve (NPres). Joshua Tree NP is a Class I air quality area, receiving the highest protection under the Clean Air Act. The other park units are Class II air quality areas, still receiving protection under the Act, but to a lesser degree.

Although most of the park units in the network are some distance from cities and pollution sources, many experience poor air quality from pollutants such as ozone, nitrogen oxides, sulfur dioxide, volatile organic compounds, particulate matter, and toxics. These air pollutants affect, or have the potential to affect, air quality and natural resources in the Mojave Desert Network, including vegetation, wildlife, soils, water quality, and visibility. High levels of ozone in the area, for example, have the potential of affecting vegetation, as well as the health of park visitors and staff. Nitrogen compounds from the atmosphere can affect soil nutrient cycling and plant species composition. Pollutant particles in the air reduce visibility and affect how far and how well we can see. Atmospheric deposition of toxic organic compounds and metals have a wide range of effects on fish and wildlife. The following sections describe air pollutant emissions, air quality monitoring, and air pollutant concerns for resources in the network.

Air Pollutant Emissions

Air quality in the network is affected primarily by pollution sources in California, Arizona, and Nevada, although more distant sources can also affect the area. Los Angeles, the San Joaquin Valley, and Las Vegas are major source areas, with significant emissions from mobile sources (e.g., cars, trucks, off-road vehicles), stationary sources (e.g., power plants and industry), and area sources (e.g., agriculture, fires, and road dust).

Figure 1 shows distribution maps for emissions of nitrogen oxides and sulfur dioxide in California, Arizona, and Nevada. Major sources of nitrogen oxides include cars and other mobile sources, compressors, power plants and industry. The major sources of sulfur dioxide are coal-burning power plants, industry, and diesel engines. Additional information on pollutant sources can be found at http://www.epa.gov/air/data/index.html.



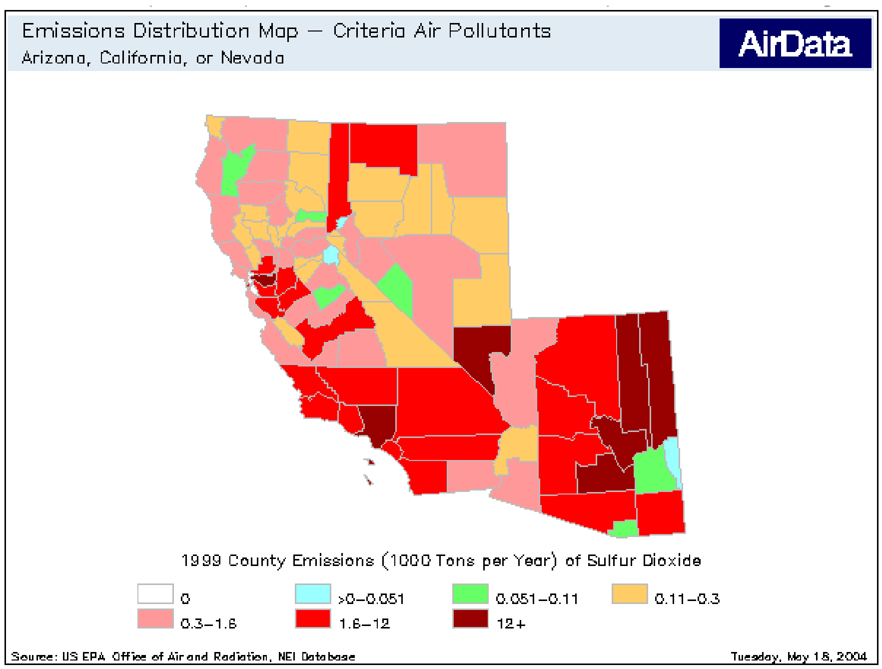


Figure 1. Distribution maps for emissions of nitrogen oxides and sulfur dioxide in California, Arizona, and Nevada.

Air Quality Monitoring

Figure 2 shows air quality monitoring in the Mojave Desert Network. Types of monitoring include ozone monitoring by the NPS Gaseous Pollutant Monitoring Network (GPMN) and ozone monitoring by States (Ozone); wet deposition (rain, snow) monitoring of atmospheric pollutants by the National Atmospheric Deposition Program (NADP); dry deposition (dryfall) monitoring of atmospheric pollutants by the Clean Air Status and Trends Network (CASTNet); and visibility monitoring by the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. The history of monitoring at each park unit can be found at http://www2.nature.nps.gov/air/Monitoring/MonHist/index.cfm.

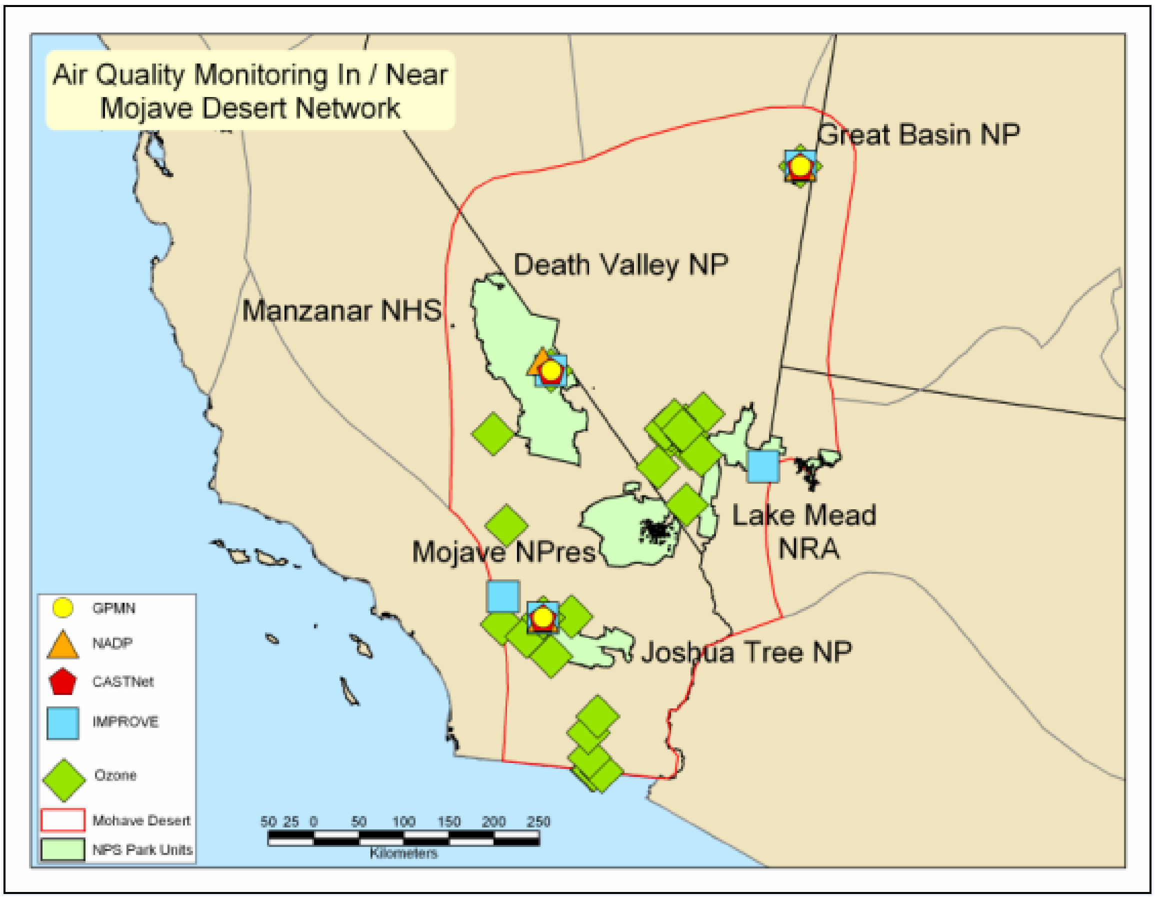


Figure 2. Air quality monitoring in the Mojave Desert Network (GPMN=NPS Gaseous Pollutant Monitoring Network for ozone; NADP= National Atmospheric Deposition Program; CASTNet= Clean Air Status and Trends Network; IMPROVE=Interagency Monitoring of Protected Visual Environments; Ozone=ozone monitoring by States.

Table 1 lists air quality monitoring sites in or near Mojave Desert Network units. Death Valley NP, Great Basin NP, and Joshua Tree NP have on-site monitoring of wet and dry deposition, visibility, and ozone. Lake Mead NRA, Manzanar NHS, and Mojave NPres have little or no monitoring.

Table 1. Air quality monitoring sites in and near NPS units in the Mojave Desert Network. Air quality data for on-site monitors can be obtained from the monitoring network websites listed below. Air quality estimates for park units without on-site monitoring are available from NPS Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm. The following table also identifies nearest monitors for inventory purposes. Data from distant monitors are unlikely to be representative of conditions in a park unit; Air Atlas estimates should be used in these cases.

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
	LOCATION	**SITE #**	**LOCATION**	**SITE #**	**LOCATION**	**SITE #**	**LOCATION**	**SITE #**
DEVA	On-site	CA95	On-site	DEV412	On-site	DEVA1	On-site	060270101
GRBA	On-site	NV05	On-site	GRB411	On-site	GRBA1	On-site	320330101
JOTR	On-site	CA67	On-site	JOT403	On-site	JOTR1	On-site (Yucca Valley 4 km NW)	060719002
							Passive ozone*	
LAME	GRCA 170 km E	AZ03	GRCA 170 km E	AZ03	GRCA 180 km E	GRCA2	Boulder City, NV 8 km W	320030601
							Passive ozone* Portable ozone**	
MANZ	DEVA 115 km E	CA95	DEVA 115 km E	CA95	DEVA 115 E	DEVA1	DEVA 115 km E	060270101
MOJA	JOTR 100 km S	CA67	JOTR 100 km S	CA67	JOTR 100 km S	JOTR1	Searchlight, NV 50 km E	320030078
	DEVA 150 km N	CA95	DEVA 150 km N	CA95	DEVA 150 km N	DEVA1	Jean, NV 35 km E	320031019

NADP/NTN = National Atmospheric Deposition Program at http://nadp.sws.uiuc.edu/
CASTNet = Clean Air Status and Trends Network at http://www.epa.gov/castnet/
IMPROVE = Interagency Monitoring of Protected Visual Environments at http://vista.cira.colostate.edu/views/
Ozone = EPA AirData at http://www.epa.gov/air/data/index.html or NPS AirWeb at http://www2.nature.nps.gov/air/data/index.htm
*Passive ozone at http://www2.nature.nps.gov/air/studies/passives.htm
**Portable ozone at http://www2.nature.nps.gov/air/studies/portO3.htm
DEVA = Death Valley NP
GRBA = Great Basin NP
JOTR = Joshua Tree NP
LAME = Lake Mead NRA
MANZ = Manzanar NHS
MOJA = Mojave NPres

Air Quality Estimates: Air Atlas

For park units without on-site monitoring, estimates of many air quality parameters can be found in Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm. Air Atlas is a mini-GIS tool that provides national maps and an associated look-up table with baseline values of air quality parameters for all Inventory and Monitoring (I&M) parks in the U.S. The values are based on averaged 1995-1999 data. Air Atlas was produced by the NPS Air Resources Division in association with the University of Denver. Air Atlas serves as the air inventory for parks.

The estimated air quality values provided in Air Atlas are based on the center of the polygon defining the park or multiple units of the park. Data from all available monitors operated by NPS, States, and EPA are used for the interpolation of the air quality values.

Air Atlas contains a comprehensive set of air quality parameters for all I&M parks. Table 2 summarizes a select group of air quality parameters for the Mojave Desert Network.

Table 2. Estimates of selected air quality parameters for units of the Mojave Desert Network (from Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm)

MOJAVE DESERT NETWORK

		Ozone --						NADP (kg/ha/yr)		Visibility - IMPROVE	
Parkname	CLASS	2ndHi1hr	4thHi8hr	#8hr>85	#1hr>100	W126	Sum06_3Mo	Wet S	Wet N	bextClear	bextHazy
Death Valley NP	2	113.3	89.6	18.2	49.1	21.0	31.6	0.38	1.12	10	66
Great Basin NP	2	97.5	75.8	1.8	3.5	30.0	15.0	0.54	1.31	5	22
Joshua Tree NP	1	146.5	102.5	26.2	104.8	13.0	49.1	0.37	0.89	10	70
Lake Mead NRA	2	103.4	82.2	7.0	19.7	48.0	25.9	0.41	1.10	8	42
Manzanar NHS	2	113.3	89.6	18.2	49.1	38.0	31.6	0.38	1.12	10	66
Mojave N PRES	2	113.3	89.6	18.2	49.1	36.0	31.6	0.38	1.12	10	66

Class: refers to an area's designation under the Clean Air Act
Ozone information represents 5-yr average of annual values from 1995-1999
- 2nd High 1 hr concentration (ppb): indicates peak values for ozone; old standard of 0.12 ppm (120 ppb) was based on 2nd hi,1-hr average
- 4th high 8 hr concentration (ppb): new ozone standard of 0.08 ppm (80 ppb) is based on 4th hi, 8-hr average
- #8 hours>85 ppb: indicates how often the area would exceed the new 8-hr standard of 0.08 ppb
- # hours> 100 ppb: high peaks in ozone concentration, as well as cumulative dose, contribute to vegetation injury
- W126 (ppm-hrs): Cumulative exposure index that assigns greater importance to higher ozone concentrations
- SUM06_3mon (ppm-hrs) - sum of hourly ozone conc.≥0.06 ppm (60 ppb) over 3 months (~ growing season), i.e., cumulative ozone dose

NADP information represents 6-yr average of annual values from 1995-2000
- NADP deposition (kg/ha/yr): estimate of pollutants deposited to ecosystem by precipitation (NADP-National Atmospheric Deposition Program)
- NADP Total S - sulfur from sulfate deposited by precipitation
- NADP Total N - inorganic nitrogen (ammonium plus nitrate) deposited by precipitation

Visibility IMPROVE information represents 5-yr average of annual values from 1995-1999
- bextClear - measure of light scattering and absorption, i.e., extinction, by particles in the air on an average clear day
- bextHazy - measure of light scattering and absorption, i.e., extinction, by particles in the air on an average hazy day

Air Quality: Monitoring and Effects

Wet Deposition of Atmospheric Pollutants

Death Valley NP, Great Basin NP, and Joshua Tree NP have on-site monitoring of wet deposition as part of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN). These sites are supported by the NPS. Monitoring began at Great Basin NP in 1985; at Death Valley NP and Joshua Tree NP in 2000. Lake Mead NRA, Manzanar NHS, and Mojave NPres are distant from any NADP/NTN monitors; estimates of wet deposition for these park units can be obtained from AirAtlas. NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year – kg/ha/yr) and pollutant concentration (in microequivalents per liter – ueg/l). Deposition varies with the amount of annual precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years, independent of rainfall fluctuations. In general, wet deposition and concentration of sulfate, nitrate, and ammonium are low in the western U.S. relative to the Midwest and East. Pollutant deposition in the Mojave Desert Network is consistent with this pattern.

A trend analysis of sulfate in precipitation (Figure 2) illustrates that sulfate is decreasing at Great Basin NP and other western parks, while increasing at others. Nitrate in precipitation (Figure 3) is increasing at some western sites, while decreasing at others. NADP/NTN monitoring at Death Valley NP and Joshua Tree NP was started in 2000, so trend data is not yet available for those sites.

Dry Deposition of Atmospheric Pollutants

Death Valley NP, Great Basin NP, and Joshua Tree NP have on-site monitoring of dry deposition since 1995 as part of the Clean Air Status and Trends Network (CASTNet). These sites are supported by the NPS. Lake Mead NRA, Manzanar NHS, and Mojave NPres are distant from any CASTNet monitors; estimates of dry pollutant concentrations for these park units can be obtained from AirAtlas.

There is insufficient long-term dry deposition data available to do a trend analysis similar to that described for wet deposition. In general, trends in dry deposition are likely to follow trends in wet deposition.

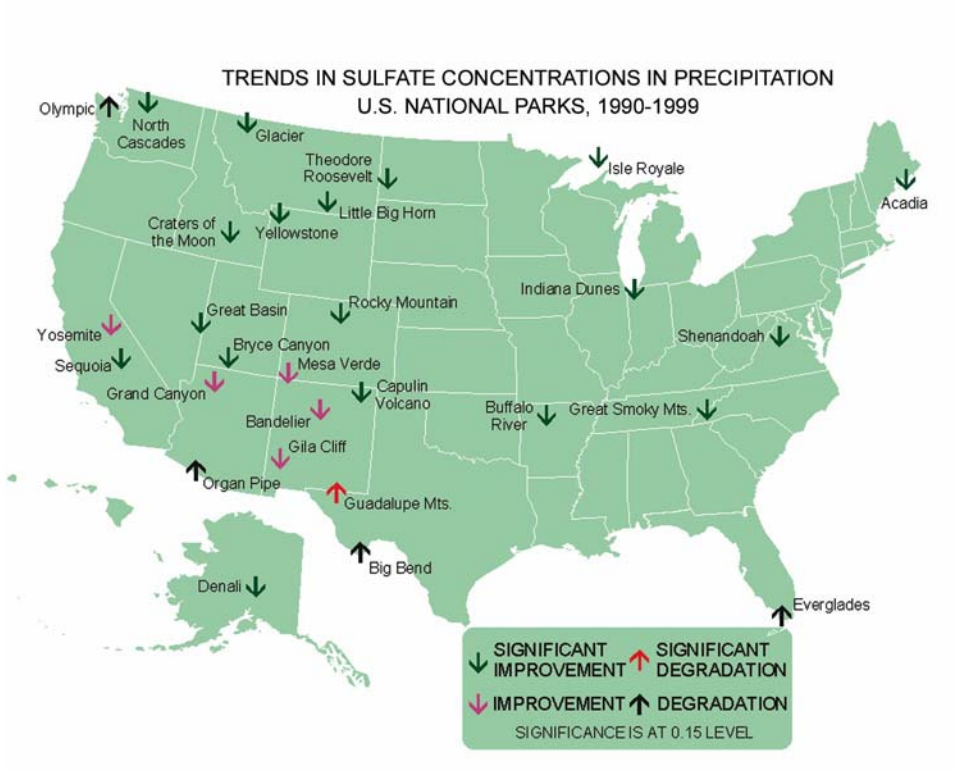


Figure 3. Trends in sulfate concentrations in precipitation from 1990-1999 show generally significant improvement at most national parks. This improvement is attributed to the reduction in sulfur dioxide emissions from electric utilities required by the 1990 amendments to the Clean Air Act.

Figure 4. Nitrate concentrations in precipitation increased at most parks from 1990-1999, with some parks showing significant increases.

Total Deposition: Current and Natural Estimates

When assessing ecosystem impacts from atmospheric deposition it is desirable to have estimates of total deposition, that is, wet plus dry deposition. Estimates of total deposition for the three Mojave Desert Network sites with wet and dry deposition sampling are given in Table 3.

Table 3. Estimates of total (wet+dry) deposition (from CASTNet at http://www.epa.gov/castnet//sites.html).

Site	Total Nitrogen	Total Sulfur
Death Valley NP	2.92	0.88
Great Basin NP	2.43	0.88
Joshua Tree NP	5.26	1.16

These estimates indicate that deposition of both nitrogen and sulfur are elevated above natural levels of deposition. Estimates of natural deposition for either sulfur or nitrogen in the West are approximately 0.25 kg/ha/yr.

Deposition Effects

Atmospheric deposition of nitrogen and sulfur compounds can affect water quality, soils, and vegetation. Both nitrogen and sulfur emissions can form acidic compounds (e.g., nitric or sulfuric acid); when deposited into ecosystems with low buffering capacity, acidification of waters or soils can occur. Ecosystems in the Mojave Desert Network are generally well-buffered, with sufficient base cations in soils and waters to neutralize acids. An exception may be high elevation alpine lakes in Great Basin NP that may not have sufficient buffering capacity. A waterbody with an acid neutralizing capacity of less than 100 microequivalents per liter may be at risk from episodic acidification (particularly during snowmelt) or chronic acidification. In addition, there may be small poorly buffered pothole ecosystems in some park units that are sensitive to acidification.

Deposition of nitrogen compounds can also have a fertilization effect on waters and soils. In some areas of the country, elevated nitrogen deposition has been shown to alter soil nutrient cycling and vegetation species composition. Areas in the Mojave Desert Network may be at risk from excess nitrogen. For example, soil nitrogen levels are significantly elevated in the northern Coachella Valley, a few kilometers from the southwest corner of Joshua Tree NP, suggesting that soil nitrogen may also be elevated in the park, with the potential to affect vegetation. Stable isotope studies have shown that soil nitrogen increases are due to increases in atmospheric deposition since the 1950's. Over time, excess nitrogen deposition may cause desert plants that have adapted to nitrogen-poor conditions to be out-competed and replaced by nitrogen-loving nonnative grasses and other exotic species. In addition to changes in species composition, there may be increases in productivity, resulting in increased biomass (i.e., fuel loading) and fire frequency. A cooperative study (NPS, University of California, Riverside, and the USDA Forest Service, Pacific Southwest Research Station) is currently underway to investigate the effects of nitrogen fertilization on soils and vegetation in Joshua Tree NP. Results from this study may be applicable to other units in the network.

Ozone

Ground-level ozone is produced by the reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. Although ozone is principally an urban problem, it and its precursor emissions can travel long distances, resulting in elevated ozone levels in national park units. Power plants, automobiles, and factories are the main anthropogenic emitters of nitrogen oxides. Vehicles and industries also emit VOCs. Natural biogenic VOC emissions are also significant in some geographic areas.

Death Valley NP and Great Basin NP have continuous ozone monitoring within the parks; Joshua Tree NP has a continuous ozone monitor in Yucca Valley, directly adjacent to the park. These sites are supported by NPS. They supply hourly ozone values that can be used to identify peak concentrations and compliance with the EPA standard, and to calculate ozone exposure metrics used to evaluate risk of injury to vegetation. A portable continuous ozone monitor has been used at Lake Mead NRA on a short-term basis. Passive ozone samplers have been used at Joshua Tree NP and Lake Mead NRA to collect weekly integrated samples of ozone, and provide a weekly average ozone concentration. Estimates of ozone peak concentrations and exposure metrics for Lake Mead NRA, Manzanar NHS, and Mojave NPres can be obtained from AirAtlas. In addition to NPS monitors, there are a number of State-operated ozone monitors in the region.

Data from these monitors has been used by the States and EPA to determine compliance with the EPA ozone standard (based on an 8-hr averaging period). Part or all of 474 counties nationwide are designated as nonattainment for either failing to meet the 8-hour ozone standard or for causing a downwind county to fail (Figure 4). Over 100 park units are in these ozone nonattainment areas. Large areas of the Mojave Desert Network are in or near nonattainment areas, an indication that they experience ozone concentrations at times harmful to visitor and staff health, and vegetation health. NPS has initiated pollution advisories in several parks nationwide warning visitors of potentially dangerous levels of ozone. Joshua Tree NP will issue alerts to visitors starting in summer 2004 if ozone reaches unhealthy levels.

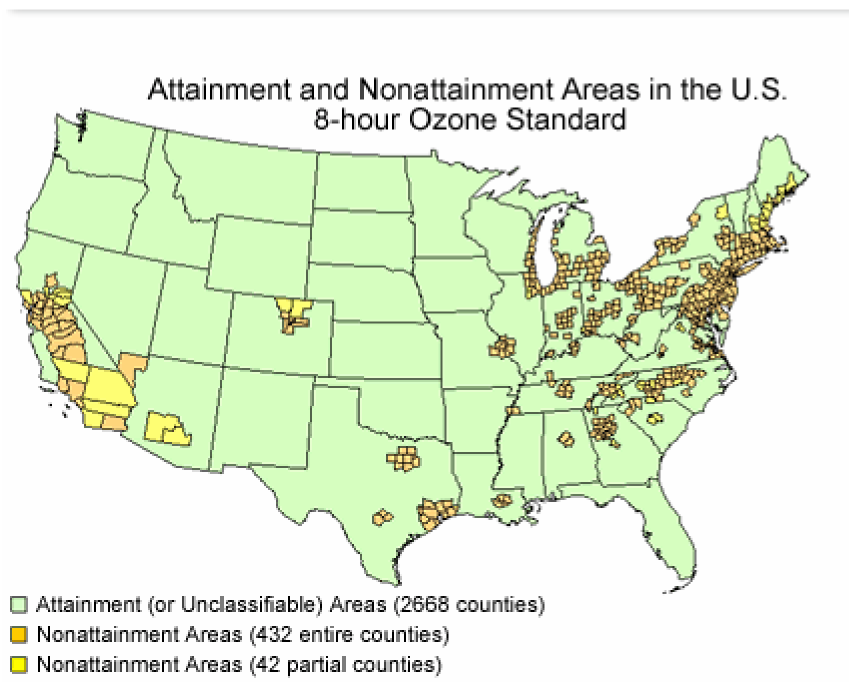


Figure 5. Attainment and nonattainment areas in the U.S. for the 8-hr ozone standard (from http://www.epa.gov/oar/oaqps/glo/designations/index.htm).

The States are required to develop plans to eventually come into compliance with the standard. It is anticipated that many areas of southern California will have difficulty doing this. Ozone is decreasing slightly in some areas of the Mojave Desert Network, but increasing in others (Figure 5).

Figure 6. Ozone concentration trends at national parks, 1990-1999. With few exceptions, ozone levels increased significantly over this 10-year period.

Ozone affects human health, causing acute respiratory problems, aggravation of asthma, temporary decreases in lung capacity in some adults, inflammation of lung tissue, and impairment of the body's immune system. In addition, ozone is one of the most widespread pollutants affecting vegetation in the U.S. Ozone enters plants through leaf stomata and oxidizes plant tissue, causing changes in biochemical and physiological processes. Both visible foliar injury (e.g., stipple and chlorosis) and growth effects (e.g., premature leaf loss, reduced photosynthesis, and reduced leaf, root, and total dry weights) can occur in sensitive plant species. Long-term exposures can result in shifts in species composition, with ozone tolerant species replacing intolerant species.

Research shows that some plants are more sensitive to ozone than humans, and effects to plants occur well below the EPA standard. Ozone causes considerable damage to vegetation throughout the world, including agricultural crops and native plants in natural ecosystems. Ozone effects on natural vegetation have been documented throughout the U.S., particularly in many areas of the East and in California. A relatively small number of national parks have been surveyed for ozone injury; injury has been documented in Great Smoky Mountains, Shenandoah, Lassen Volcanic, Sequoia/Kings Canyon, and Yosemite National Parks. Limited assessments in Joshua Tree NP in the 1980s did not document ozone injury to vegetation growing naturally in the field; however, no assessment was made of other ozone effects, e.g., growth effects. A study of *Rhus trilobata* (skunkbush) conducted from 1987-1989 in a park biomonitoring plot demonstrated that under irrigated conditions the plants showed typical ozone injury symptoms, demonstrating that ozone levels are sufficiently high in Joshua Tree NP to induce foliar injury under certain conditions, and may also cause growth effects.

Scientists use various metrics to describe ozone exposure to plants, in addition to the 1-hour or 8-hour average concentrations reported by EPA. These metrics, the Sum06 and the W126, are believed to be biologically relevant, as they take into account both peak ozone concentrations and cumulative exposure to ozone. Hourly concentrations from a continuous or portable continuous ozone analyzer are needed to calculate either metric.

Sum06 -- The running 90-day maximum sum of the 0800-2000 hourly ozone concentrations of ozone equal to or greater than 0.06 ppm. The Sum06 is expressed in cumulative ppm-hr. Several thresholds have been developed for Sum06:

Natural Ecosystems	8 - 12 ppm-hr	(foliar injury)
Tree Seedlings	10 - 16 ppm-hr	(1-2% reduction in growth)
Crops	15 - 20 ppm-hr	(10% reduction in 25-35% of crops)

W126 -- A cumulative index of exposure that uses a sigmoidal weighting function to give added significance to higher concentrations of ozone while retaining and giving less weight to mid and lower concentrations. The number of hours over 100 ppb (N100) is also considered in assessing the possible impact of the exposure. The W126 index is in cumulative ppm-hr. Several thresholds have been developed for W126:

	W126	N100
Highly Sensitive Species	5.9 ppm-hr	6
Moderately Sensitive Species	23.8 ppm-hr	51
Low Sensitivity	66.6 ppm-hr	135

In a natural ecosystem, many other factors can ameliorate or magnify the extent of ozone injury at various times and places such as soil moisture, presence of other air pollutants, insects or diseases, and other environmental stresses.

Ozone sensitive and bioindicator plant species have been identified at Death Valley NP, Great Basin NP, Joshua Tree NP, Lake Mead NRA, and Mojave NPres (Tables 4 and 5). These species were identified by cross-referencing NPSpecies with sensitive species identified in “Ozone Sensitive Plant Species on National Park Service and U.S. Fish and Wildlife Service Lands” (2003) at http://www2.nature.nps.gov/air/Pubs/BaltFinalReport1.pdf. The lack of ozone sensitive or bioindicator species at Manzanar NHS may be due to incomplete NPSpecies lists or lack of information on the ozone sensitivity of species in the area.

Sensitive species are those that typically exhibit foliar injury at or near ambient ozone concentrations in fumigation chambers and/or are species for which ozone foliar injury symptoms in the field have been documented by more than one observer. Bioindicator species for ozone injury meet all or most of the following criteria: 1) species exhibit foliar symptoms in the field at ambient ozone concentrations that can be easily recognized as ozone injury by subject matter experts, 2) species ozone sensitivity has been confirmed at realistic ozone concentrations in exposure chambers, 3) species are widely distributed regionally, and 4) species are easily identified in the field. Because of these attributes, bioindicator species are recommended for field surveys to assess ozone injury.

NPS is currently conducting a risk assessment for parks, based on the concept that foliar ozone injury on plants is the result of the interaction of the plant, ambient ozone, and the environment. That is, the risk for foliar injury is high if three factors are present: species of plants that are genetically predisposed to ozone, concentrations of ambient ozone that exceed a threshold required for injury, and environmental conditions, primarily soil moisture, that foster gas exchange and the uptake of ozone by the plant. This risk assessment will be useful to resource managers in deciding whether to conduct future ozone monitoring or foliar injury assessments.

Ozone concentrations and cumulative exposures are sufficient to induce ozone injury under certain conditions at several of the units in the Mojave Desert Network. The draft risk assessment for the Mojave Desert Network indicates that the risk for ozone injury is high at Joshua Tree NP, Manzanar NHS, and Mojave NPres, and low at Death Valley NP, Great Basin NP, and Lake Mead NRA. The final assessment should be available by late summer 2004.

Table 4. Ozone sensitive plant species in the Mojave Desert Network.

MOJAVE NETWORK			
Ozone Sensitive Species*			
Park Code	**Park**	**Standard Scientific Name**	**Common Name**
DEVA	Death Valley NP	Ailanthus altissima	Tree-of-heaven
DEVA	Death Valley NP	Artemisia douglasiana	Mugwort, sagewort
DEVA	Death Valley NP	Robinia pseudoacacia	Black locust
DEVA	Death Valley NP	Salix gooddingii	Gooding's willow
DEVA	Death Valley NP	Sambucus mexicana	Mexican elder
GRBA	Great Basin NP	Apios americana	Groundnut
GRBA	Great Basin NP	Apocynum androsaemifolium	Spreading dogbane
GRBA	Great Basin NP	Apocynum cannabinum	Dogbane, Indian hemp
GRBA	Great Basin NP	Asclepias incarnata	Swamp milkweed
GRBA	Great Basin NP	Asclepias syriaca	Common milkweed
GRBA	Great Basin NP	Aster macrophyllus	Big-leaf aster
GRBA	Great Basin NP	Cercis canadensis	Redbud
GRBA	Great Basin NP	Clematis virginiana	Virgin's bower
GRBA	Great Basin NP	Corylus americana	American hazelnut
JOTR	Joshua Tree NP	Eupatorium rugosum	White snakeroot
JOTR	Joshua Tree NP	Fraxinus americana	White ash
JOTR	Joshua Tree NP	Fraxinus pennsylvanica	Green ash
JOTR	Joshua Tree NP	Gaylussacia baccata	Black huckleberry
JOTR	Joshua Tree NP	Liquidambar styraciflua	Sweetgum
JOTR	Joshua Tree NP	Liriodendron tulipifera	Yellow-poplar
LAME	Lake Mead NRA	Parthenocissus quinquefolia	Virginia creeper
LAME	Lake Mead NRA	Philadelphus coronarius	Sweet mock orange
LAME	Lake Mead NRA	Pinus pungens	Table-mountain pine
LAME	Lake Mead NRA	Pinus rigida	Pitch pine
LAME	Lake Mead NRA	Pinus virginiana	Virginia pine
LAME	Lake Mead NRA	Platanus occidentalis	American sycamore
MOJA	Mojave NPres	Populus tremuloides	Quaking aspen
MOJA	Mojave NPres	Prunus serotina	Black cherry
MOJA	Mojave NPres	Prunus virginiana	Choke cherry
MOJA	Mojave NPres	Rhus copallina	Winged sumac
MOJA	Mojave NPres	Robinia pseudoacacia	Black locust

***** Species considered "sensitive" are those that typically exhibit foliar injury at or near ambient ozone concentrations in fumigation chambers and/or are species for which ozone foliar injury symptoms in the field have been documented by more than one observer. This list was developed by cross-referencing NPSpecies with sensitive species identified in "Ozone Sensitive Plant Species on National Park Service and U.S. Fish and Wildlife Service Lands" (2003) at http://www2.nature.nps.gov/air/Pubs/BaltFinalReport1.pdf.

Table 5. Ozone bioindicator plant species in the Mojave Desert Network.

MOJAVE NETWORK			
Ozone Bioindicator Species**			
Park Code	**Park**	**Standard Scientific Name**	**Common Name**
DEVA	Death Valley NP	Ailanthus altissima	Tree-of-heaven
DEVA	Death Valley NP	Artemisia douglasiana	Mugwort, sagewort
DEVA	Death Valley NP	Sambucus mexicana	Mexican elder
GRBA	Great Basin NP	Artemisia ludoviciana	Silver wormwood
GRBA	Great Basin NP	Oenothera elata	Evening primrose
GRBA	Great Basin NP	Pinus ponderosa	Ponderosa pine
GRBA	Great Basin NP	Populus tremuloides	Quaking aspen
GRBA	Great Basin NP	Rhus trilobata	Skunkbush
GRBA	Great Basin NP	Sambucus racemosa	Red elderberry
JOTR	Joshua Tree NP	Artemisia ludoviciana	Silver wormwood
JOTR	Joshua Tree NP	Rhus trilobata	Skunkbush
JOTR	Joshua Tree NP	Sambucus mexicana	Blue elderberry
LAME	Lake Mead NRA	Artemisia ludoviciana	Silver wormwood
LAME	Lake Mead NRA	Pinus ponderosa	Ponderosa pine
LAME	Lake Mead NRA	Rhus trilobata	Skunkbush
MOJA	Mojave Npres	Artemisia douglasiana	Mugwort
MOJA	Mojave Npres	Rhus trilobata	Skunkbush
MOJA	Mojave Npres	Sambucus mexicana	Blue elderberry

****** Bioindicator species for ozone injury meet all or most of the following criteria:

- species exhibit foliar symptoms in the field at ambient ozone concentrations that can be easily recognized as ozone injury by subject matter experts
- species ozone sensitivity has been confirmed at realistic ozone concentrations in exposure chambers
- species are widely distributed regionally
- species are easily identified in the field

This list was developed by cross-referencing NPSpecies with bioindicator species identified in "Ozone Sensitive Plant Species on National Park Service and U.S. Fish and Wildlife Service Lands" (2003) at http://www2.nature.nps.gov/air/Pubs/BaltFinalReport1.pdf.

Visibility
Visibility-impairing particles and gases are monitored nationwide through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Death Valley NP, Great Basin NP, and Joshua Tree NP have on-site visibility monitoring. Each has a fine particle sampler that measures the types and amounts of particles that obscure visibility. Great Basin NP also has a transmissometer that measures light extinction resulting from fine particles of pollution. Joshua Tree NP has a webcam that records visibility conditions, as well as ozone concentrations that are updated every 15 minutes and available at http://www2.nature.nps.gov/air/WebCams/index.htm. Lake Mead NRA, Manzanar NHS, and Mojave NPres are distant from any IMPROVE monitors; estimates of visibility conditions for these park units can be obtained from AirAtlas.

Visibility is degraded from natural conditions in all network units. Trend analysis indicates that visibility is improving slightly on the 20 percent clearest days (Figure 6) and worsening on the 20 percent haziest days (Figure 7). States are required to develop plans to make progress towards the national goal of "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution." Regional planning organizations are currently discussing these plans. The regional planning group for the western U.S. is the Western Regional Air Partnership (WRAP), with information at www.wrapair.org.

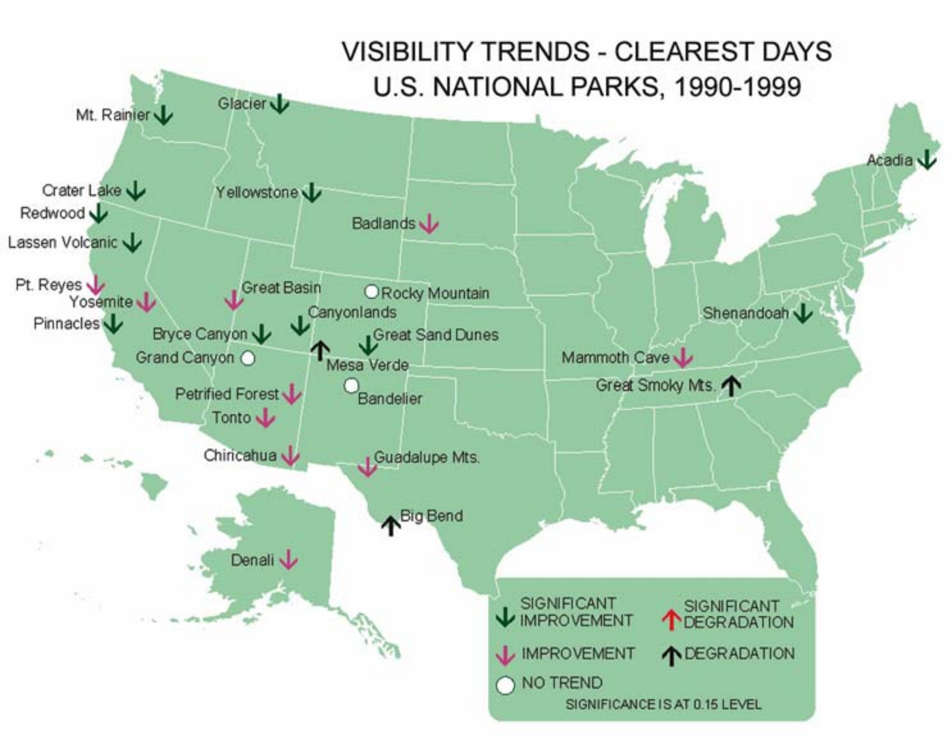


Figure 7. Trends in best visibility conditions (annual average haze levels of the 20 percent clearest days) from 1990-1999. Nearly all parks show some improvement in visibility conditions on the clearest days.

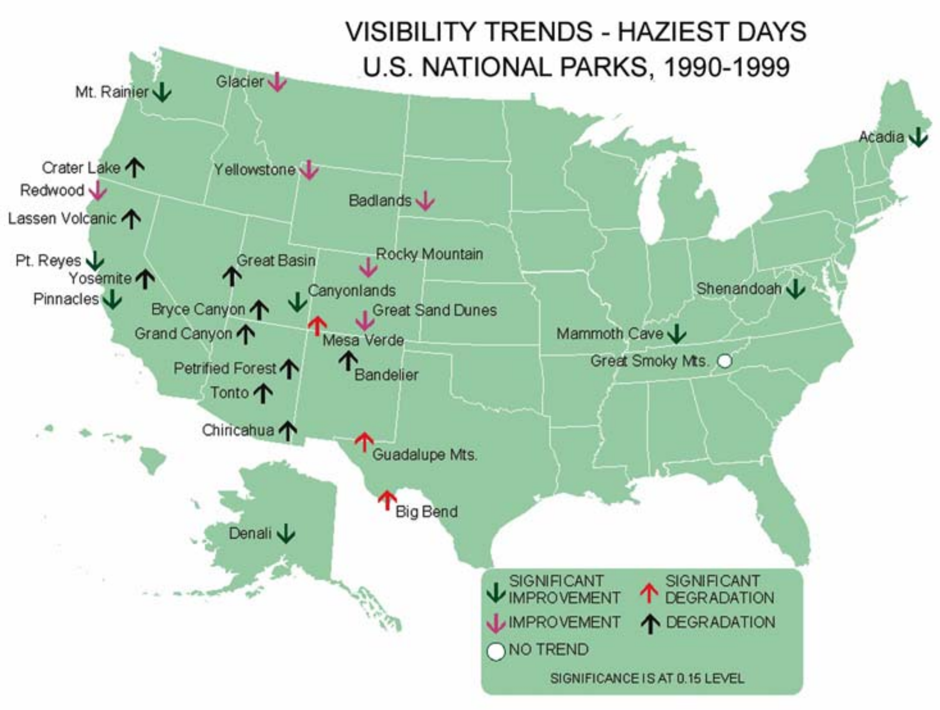


Figure 8. Trends in worst visibility conditions (annual average haze levels of the 20 percent haziest days) from 1990-1999. Most parks show at least some degradation or worsening of visual conditions on the haziest days, especially in the southwestern U.S.

Toxic Air Pollutants

The Mercury Deposition Network collects rainfall for mercury analysis at over 60 sites nationwide. There are no monitoring sites in or near the Mojave Desert Network. There are statewide fish consumption advisories because of mercury contamination in Nevada, California, and Arizona. Sources of mercury include atmospheric deposition, mining activities, and natural sources. Coal contains mercury and large coal-burning power plants are major sources of mercury to the atmosphere and, eventually, terrestrial and aquatic ecosystems.

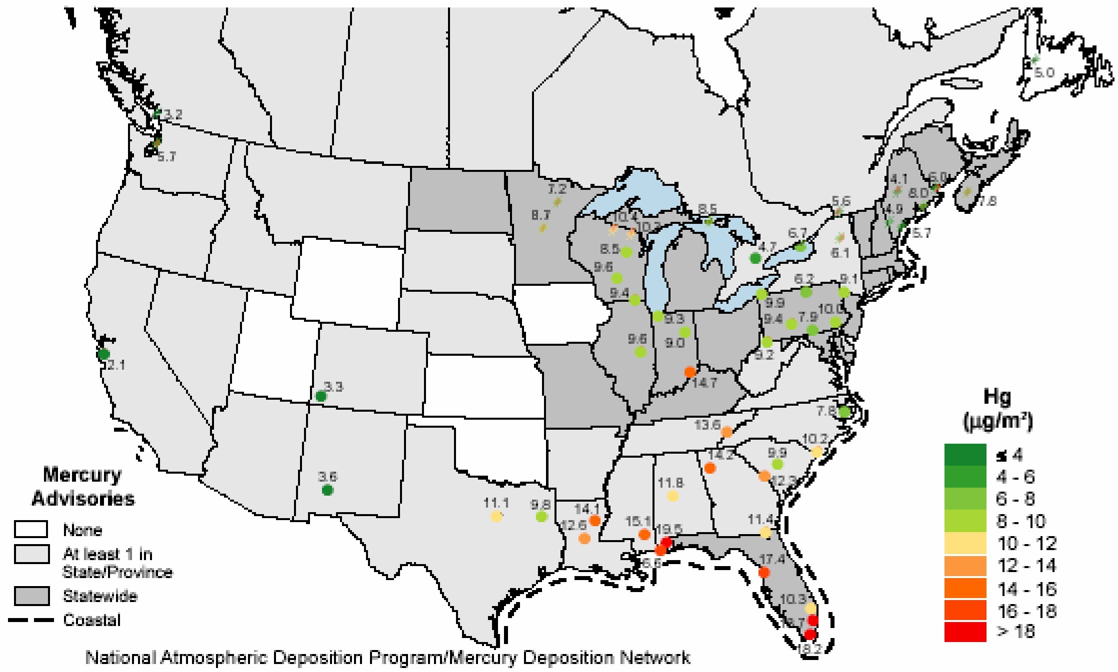


Figure 9. Total mercury in wet deposition (micrograms per cubic meter). Mercury advisories are for fish and wildlife consumption. (from Mercury Deposition Network at http://nadp.sws.uiuc.edu/mdn/.

Recommendations

Death Valley NP, Great Basin NP, and Joshua Tree NP are well represented by on-site ozone, atmospheric deposition, and visibility monitors. However, it is important to note that individual monitors in very large parks may not represent air quality conditions in all parts of the park. All monitoring currently underway should be continued to provide long-term air quality information for the network.

Lake Mead NRA, Manzanar NHS, and Mojave NPres do not have continuous on-site monitoring. Lake Mead NRA has nearby State-operated ozone monitors, as well as information from on-site passive ozone samplers. The network may want to consider adding air quality monitoring to these units. In particular, because of its size and ecological significance, it may be desirable to initiate air quality monitoring in Mojave NPres, particularly for ozone and wet and dry deposition.

Joshua Tree NP and Mojave NPres may want to initiate plant surveys for ozone injury, as the risk for ozone injury is high in these areas. Risk for injury is also high in Manzanar NHS, but ozone sensitive species have not been identified in the unit.

Nitrogen deposition has the potential to alter vegetative communities in the network. A study is now underway at Joshua Tree NP to evaluate nitrogen effects; similar studies may be useful at other network units.

There is little information on atmospheric deposition of toxic pollutants in the Mojave Desert Network. A Mercury Deposition Network (MDN) sampler at Great Basin NP would provide valuable information on mercury deposition.

Relevant Websites
NPS AirWeb at http://www2.nature.nps.gov/air/
Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm
NADP at http://nadp.sws.uiuc.edu/
MDN at http://nadp.sws.uiuc.edu/mdn/
CASTNet at http://www.epa.gov/castnet/
EPA Ozone (AirData) at http://www.epa.gov/air/data/index.html
NPS Ozone Data at http://www2.nature.nps.gov/air/data/index.htm
IMPROVE at http://vista.cira.colostate.edu/views/
Pollution sources and air quality data at http://www.epa.gov/air/data/index.html